

Thornycroft, with his turbine propeller, is able to emphasize this economy of weight still further, and, but for difficulties of going astern not yet surmounted, would be able to save considerable weight and space in sea-going steamers with this contrivance.

As regards their construction, turbines are divided into three classes (p. 24)—the radial, axial, and mixed-flow—according to the mode in which the water enters and passes through the turbine; but as regards the dynamical principle on which the turbines work, they are divided into two classes (p. 25), the *reaction* and the *impulse* turbine.

In the reaction or Jonval turbine, described in chapters iii. to vi., the passages are completely filled with water, and the changes of pressure play an important part in the work performed. This turbine possesses the advantage of being able to work when drowned by the tail race, or when elevated above the tail water to a height anything less than the height of the water barometer, a suction tube of properly adjusted shape being fitted below the turbine to carry off the water at pressure gradually increasing downwards to the atmospheric pressure. Against this are the disadvantages of imperfect regulation for varying load, and that with a high fall this turbine must be made so small and must run so fast as rapidly to wear out, as in the Fourneyron turbines at St. Blaise (p. 422); but this disadvantage the author professes (p. 263) to avoid by compounding the turbine, just as we compound the steam-engine with high-pressure steam.

The impulse or Girard turbine, on the other hand (chapters vii. and viii.), derives its power entirely from the change of momentum of the water without change of pressure; the buckets are freely ventilated, and consequently this turbine can only work in communication with the surrounding air. It possesses, too, the great advantage of complete regulation of power by merely altering the supply of water. Girard turbines are divided into outward flow (Fourneyron) turbines, and inward flow (James Thomson); the latter, although more weighty and costly, possessing the advantage of greater stability of motion.

In their difference of action we may compare the Jonval turbine with the screw propeller, which works entirely immersed, and derives its reaction partly from the change of pressure in the water; while the Girard turbine resembles the paddle-wheel in working at the surface of separation of the water and air, so that no appreciable change of pressure is manifest. Against this analogy, however, we find the screw propeller far less susceptible to changes of immersion than the paddle-wheel, whence the manifest superiority of the screw for long voyages.

In chapters ix. to xi. the author gives a very valuable collection of numerical applications of his theories to actual turbines on a large scale. In designing a turbine to utilize a fall, the first important measurement is that of the quantity of the stream of water; the speed of the turbine is next determined from the consideration that the best theoretical speed is half (or a little more than half) the speed at which the turbine would run if unloaded; and then various practical considerations intervene in deciding whether the turbine should be reaction or impulse, outward, inward, or mixed flow.

At Holyoke, Mass., the Water-Power Company, under Mr. James B. Francis, controlling the falls of the Connecticut, undertake the commercial testing of turbines submitted to them, and have checked to some extent the wild claims of efficiency, reaching and even exceeding 100 per cent., which American turbine makers are said to have claimed in their advertisements. There is still, however, an efficiency claimed for American turbines which has not been rivalled in Europe: this cannot be attributed to defect in our designs, and the author thinks must be attributed to the less care bestowed in America on the measurement of the quantity of water consumed. It is noticeable that the American turbines are generally of the reaction Jonval type, which is more suitable for their unlimited supplies of water by reason of its smaller weight and cost; here in Europe, where water is scarcer, the impulse Girard turbine is more in favour.

For mining purposes, especially in California, with great falls of 400 or 500 feet and small quantities of water, the hurdy-gurdy or Pelton wheel (p. 419) is a favourite, and in a paper by Mr. Hamilton Smith, Jun., of the American Society of Civil Engineers, the efficiency of this wheel and its practical advantages are declared to be very high. Similar small impulse turbines seem likely to come into general domestic use.

The author concludes (chapter xiii.) with a description of the various hydraulic pressure engines and motors of Armstrong, Rigg, and others. These engines act by pressure only, like the steam-engine, with the disadvantage of using the same quantity of water whether working at high or low power, except in the case of Mr. Rigg's motor. Such motors are, however, coming into great use on ships, not only for working the guns, but for steering, loading, and discharging cargo.

Although designed, and amply fulfilling its purpose, as a practical treatise on hydraulic motors, this book will provide the pure theorist with some of the most elegant applications of relative velocity, aberration, dynamical principles, and of hydromechanics; and it is instructive to notice that, as in all practical mechanical treatises, gravitation units of force only are employed, even in the hydrodynamical equations of Borda and Carnot, or of Bernoulli, as we think they should be called. All this is in direct opposition to the theoretical text-books; theorist or practical man, which is to give way?

A. G. G.

PHYSIOLOGY OF EDUCATION.

Physiological Notes on Primary Education and the Study of Language. By Mary Putnam Jacobi, M.D. (New York and London: G. P. Putnam's Sons, 1889.)

THIS is a remarkable book. The authoress is an original thinker who knows how to express her thoughts clearly and strongly. It is worthy of being read by all interested in the science of education, though few perhaps even of the advocates of the present educational renaissance would be prepared to receive every one of her conclusions.

The work consists of four distinct essays. The first two are entitled "An Experiment in Primary Education," and describe the way in which Dr. Mary Jacobi taught

her own little girl. She commences the account with some very valuable remarks on the right order of studies.

"The first intellectual faculties to be trained are perception and memory. The subjects of the child's first studies should therefore be selected, not on account of their ultimate utility, but on account of their influence upon the development of these faculties. What sense is there then in beginning education with instruction in the arts of reading and writing? . . . From the modern standpoint, that education means such an unfolding of the faculties as shall put the mind into the widest and most effective relation with the entire world of things—spiritual and material,—there is an exquisite absurdity in the time-honoured method. To study words before things tends to impress the mind with a fatal belief in their superior importance."

As forms and colours are the elements of all visual impressions, Dr. Jacobi began to teach her child geometrical forms before she was four years of age. At four and a half the little girl began elementary colours. Afterwards she made acquaintance with the points of the compass, the main ideas of perspective, and then maps and geography. The study of number, of course by concrete illustrations, followed that of form and outline. The observation of natural objects, especially that of plants and plant-life, was then commenced. The growth of beans and hyacinths was carefully watched, and the daily observations made by the child were written down by the mother, till she attempted them herself, and became gradually initiated into the mysteries of writing. This led her on easily to the art of reading when she was about six years of age. The progress of the child's mental development during these early years is fully described, with many pleasant recollections of her sayings.

The third part consists merely of a criticism of Miss Youman's views on the teaching of botany, and an argument in favour of commencing in a child's education with the flower rather than the leaf.

Half the book, however, is occupied by the fourth essay, in which the authoress treats of "The Place for the Study of Language in a Curriculum of Education." Of course she places it after the mind has been trained to deal with sense perceptions of external objects; but she contends earnestly for the importance of the study of words, especially for the power it possesses of enabling the child to form abstract conceptions. The authoress enters largely into the brain action involved in the use of verbal signs or complex ideas, and illustrates her views of the matter by means of physiological diagrams. She also describes a little device for the comparison of verbal roots, which she terms "language tetrahedrons," and which are intended to show the relation between Latin, French, German, and English. She would devote to literary studies, including English, the best part of the time between the Kindergarten training and the age of fourteen.

"To the study of words may be brought the scientific methods used in the study of things—observation, analysis, comparison, classification; and the child may thus begin to be trained for physical science at a time when the pursuit of most physical sciences is impossible."

It may be that Dr. Mary Jacobi claims too much time for the study of language, but the old-fashioned educationists will get little consolation from her concessions; for she not only places the study of words after that of things,

but she would have several forms of Aryan speech studied simultaneously, and she would postpone the study of grammar till two years after the serious study of language has commenced. She believes that the power of abstraction and the general mental training gained by these philological studies will enable the young person at an early age to enter upon more serious matters of study or those of more immediate practical utility.

J. H. G.

OUR BOOK SHELF.

Steam-Engine Design. By Jay M. Whitham, Professor of Engineering, Arkansas Industrial University. (London: Macmillan and Co., 1889.)

In this work the author treats of the application of the principles of mechanics to the design of the parts of a steam-engine of any type or for any duty. He acknowledges that he has culled as much information as he has required from well-known sources, both English and American; and he has embodied, as a sort of foundation for his work, a course of lectures given to his class at the United States Naval Academy by P.A. Engineer John C. Kafer, U.S.N.

After careful study, we can say that the book appears to be well suited for its purpose. The arrangement of information, both principles and details, is much the same as that in Mr. A. E. Seaton's excellent work on marine engineering; but the field covered is of far less extent, and the boiler and its accessories are not included. The author being a Professor of Engineering in an American University, we expected to find some variations from our own practice in steam-engine design. In this, however, we were disappointed. A few of the woodcuts represent parts of engines differing in insignificant details from those used in this country, but the main design is practically the same. It is gratifying to find many of our own engineers quoted as authorities in the volume—viz. D. K. Clark, A. E. Seaton, R. Sennett, and many other well-known English authorities.

It must not be supposed that there is no original work in this book. Chapters ii. and iii. for instance, on the design of slide valves and reversing gears, are ample evidence of hard work on the part of the author: his descriptions and diagrams of the various motions are excellent. Chapter iv. deals with the general design and proportions of the steam-chest, valves with their various connections. Chapters v. and vi. are on compound and triple-expansion engines, and contain also a theoretical treatment of indicator diagrams of a compound engine. These chapters are well written, and contain much useful information, but as a whole they do not teach anything new. To chapters vii. and viii., written by P.A. Engineer Asa M. Mattice, U.S.N., the same remarks will apply. The remaining chapters deal with the design of the various other parts of a steam-engine. The methods used are those well understood in every drawing-office worthy of the name, and they need not be further noticed here.

Taken as a whole, the book deserves praise for good and careful work; and we may especially call attention to the theoretical considerations, which are always clearly expressed. Although published by Messrs. Macmillan, the work is from an American press, that of Messrs. Ferris Bros., New York. The printing and woodcuts are excellent—far better, as usual, than English work of the same class.

N. J. L.

Coloured Analytical Tables. By H. W. Hake, Ph.D., F.I.C., F.C.S. (London: George Phillip and Son, 1889.)

NOVELTIES in text-books of elementary qualitative analysis are usually conspicuous by their absence, but the